EXPERIMENT -4
DARLINGTON AMPLIFIER

AIM: To design a Darlington amplifier with following specifications and to verify the gain at different stages.

DESIGN SPECIFICATIONS:

Vcc =12v, R1=1M, R2=1.5M, Re=2.2k, NPN transistor with β value 100.

SOFTWARE SIMULATION:

Software used: Multisim Analog Devices Edition 14.0

Procedure:

1. Switch ON the computer and open the Multisim software

2. Observe Design tool box, Instrumentation tool box, component tool box and its component functionality

3. From above tool boxes, Connect the circuit using the designed values of each and every component

4. Connect the function generator with sine wave of 6v p-p as input at the input terminals of the circuit. (Or) use signal source.

5. Connect the Cathode Ray Oscilloscope (CRO) to the output terminals of the circuit.

6. Go to simulation button click it for simulation process.

7. From the CRO observe the following values:

- Input voltage Vi
- Output voltage V
- Voltage Gain Av = 1
- Current Gain Ai = Max = 100*100
- Phase Shift = 0^o

8. Calculate the input impedance of the circuit and prove input impedance of Darlington pair is greater than CC Amplifier.

Design Calculations:

Given Data:

$I_c = 2.5mA$

$\beta=100$

$V_{cc} = 12V$

Calculation of Re:

QPoint(V_{ce}, I_c) = (6V,2.5mA)

$R_e = V_{ce}/ I_c = 6V/2.5mA = 2.4k\Omega$

Calculation of R1 and R2:

Voltage acting at base = (6+0.7+0.7) V

By Appling Voltage division,

12*R2/ (R1+R2) = 7.4

R1 = 0.639R2

We know that,

$R2 \ll \beta^2 * 2.4k\Omega$ $R2 \ll 10000*2.4k\Omega$

$R2 < 24M\Omega$

$$\boxed{\begin{array}{l} R2=1.5M\Omega \\ R1 = 1M\,\Omega \end{array}}$$

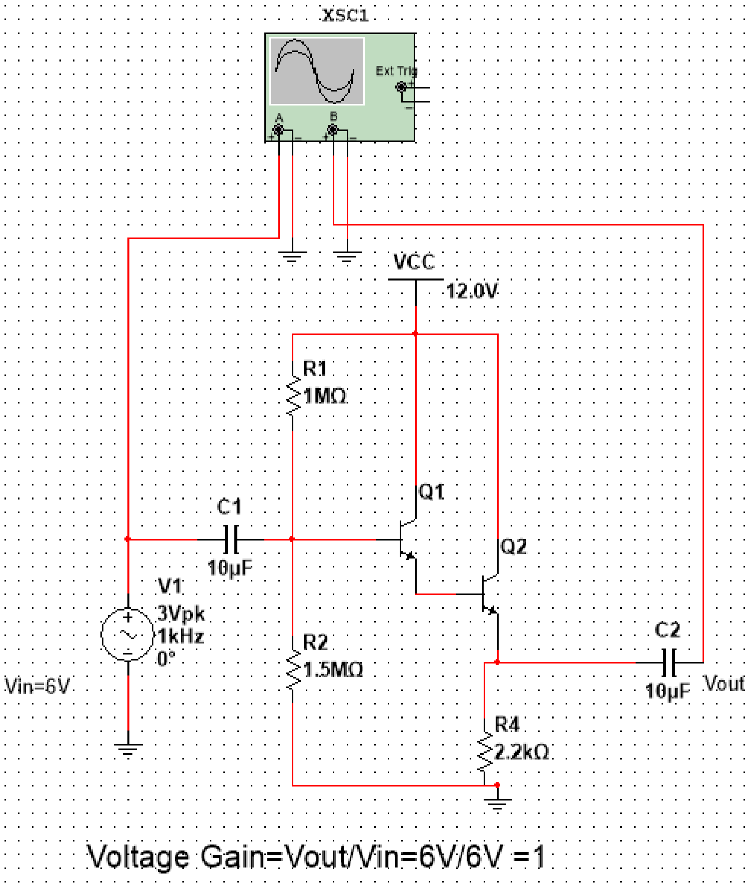
THEORETICAL CALCULATION OF INPUT RESISTANCE:

$Rs = R1||R2||\beta^2 Re$

$Rs = (1M||1.5M||10000*2.4K)\Omega$

$$\boxed{Rs = 600K\,\Omega}$$

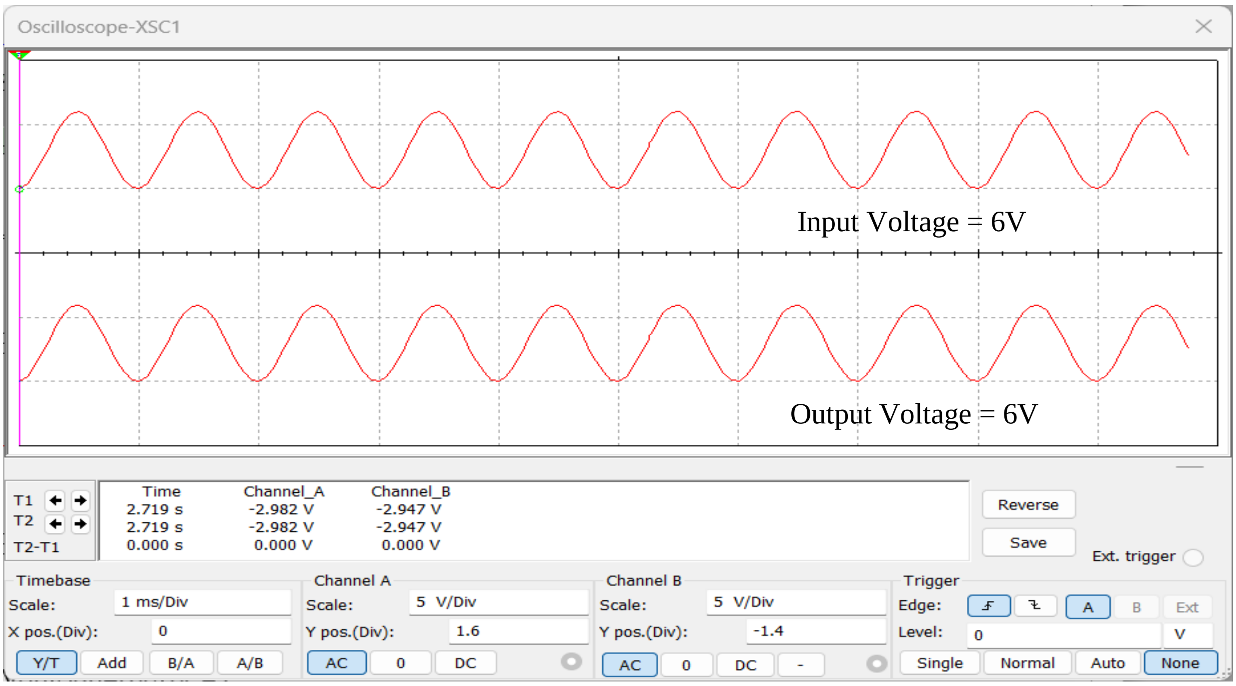
SIMULATION OF THE DESIGN:



Darlington Amplifier circuit

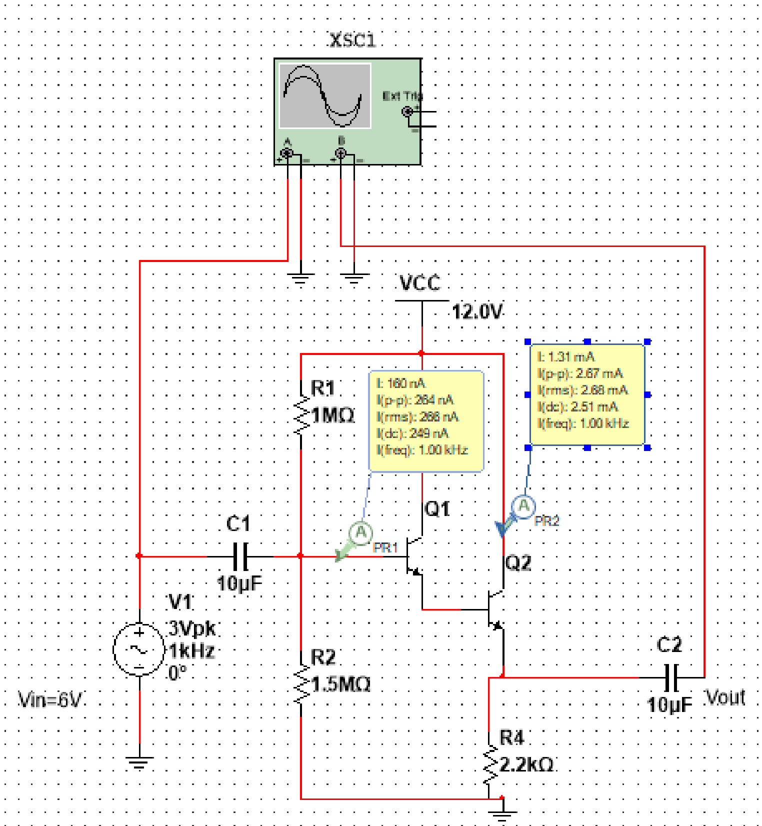
❖ **OBSERVATIONS:**

Voltage Gain:



Conclusion:
Voltage Gain of Darlington Amplifier is 1.

Current Gain:



Conclusion:

I_{in} = 264 nA

I_{out} = 267mA

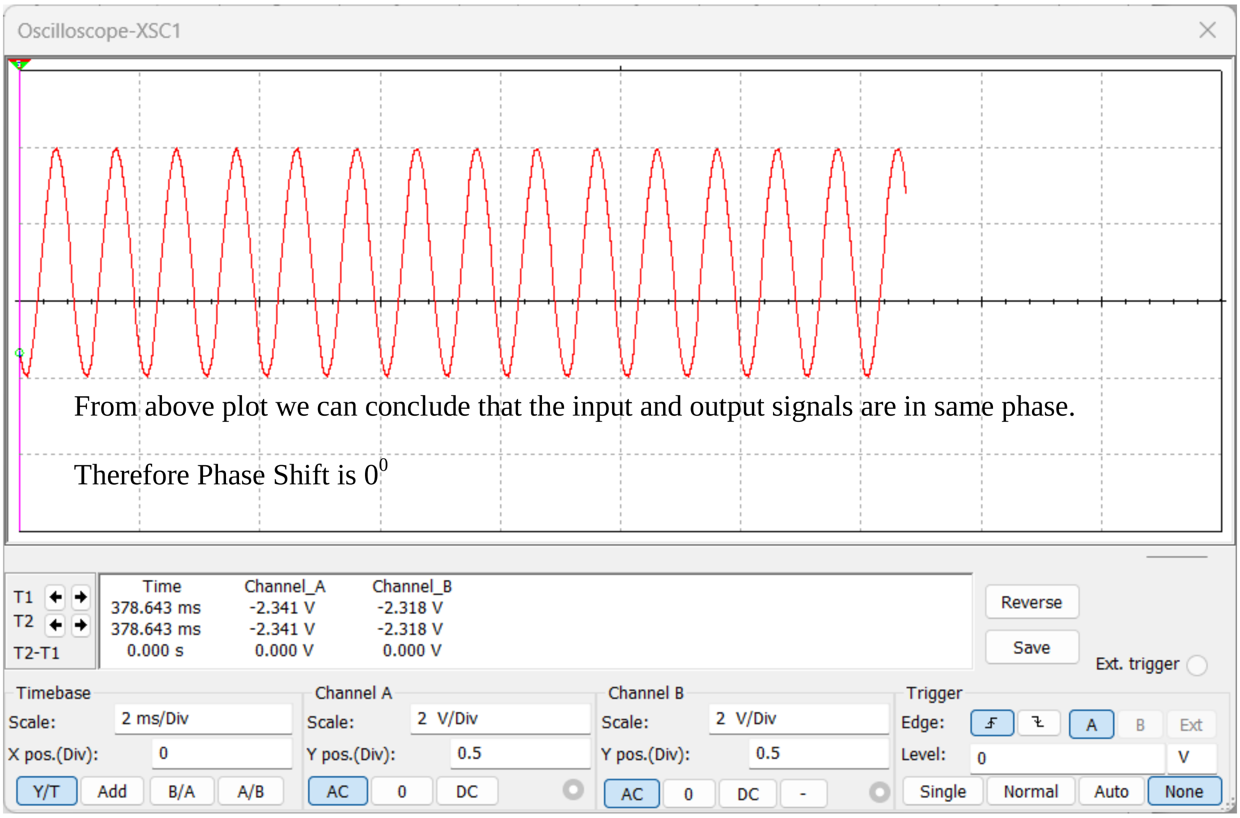
$A_i = I_{out} / I_{in}$

= 267mA/264nA

A_i = 10000 = 100*100

= hfe *hfe

Phase Shift:

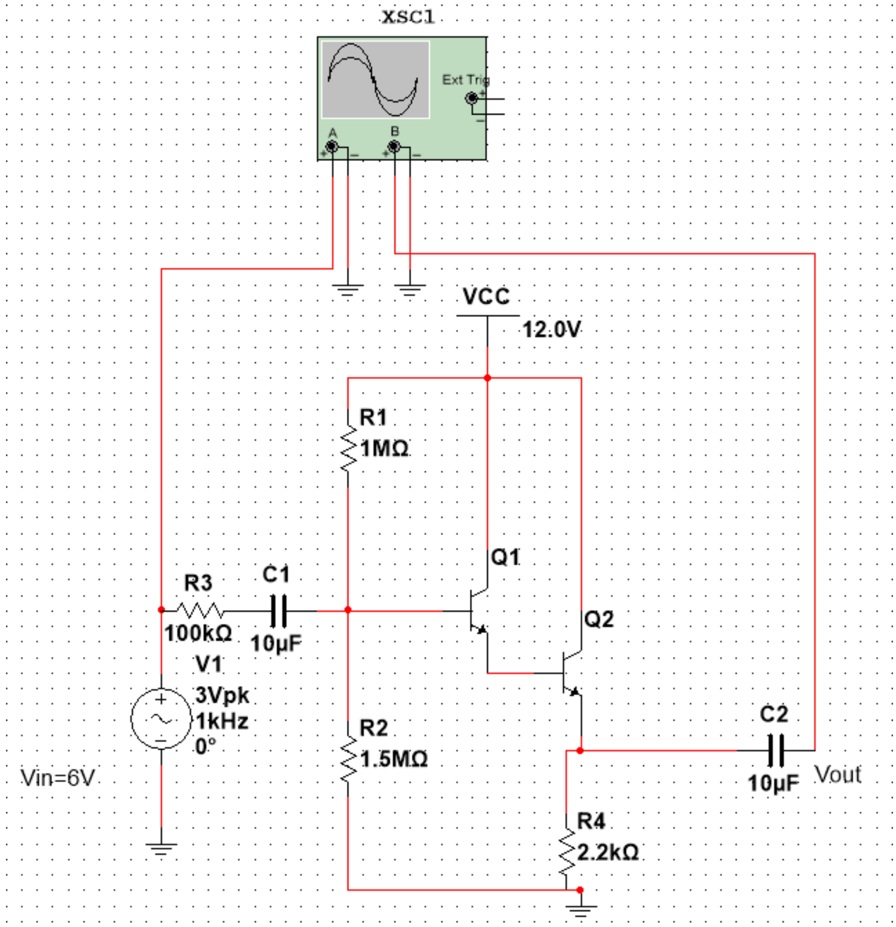


From above plot we can conclude that the input and output signals are in same phase.

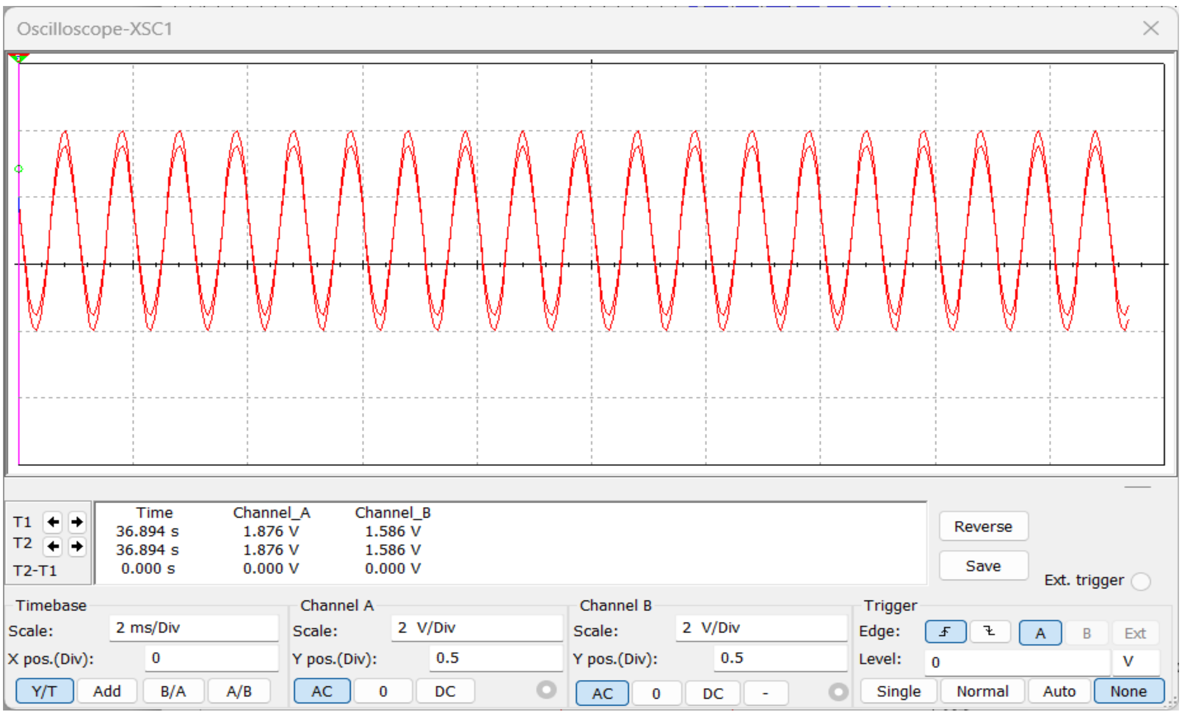
Therefore Phase Shift is 0^0

PRACTICAL CALCULATION OF INPUT RESISTANCE:

Case 1: Rin=100kΩ



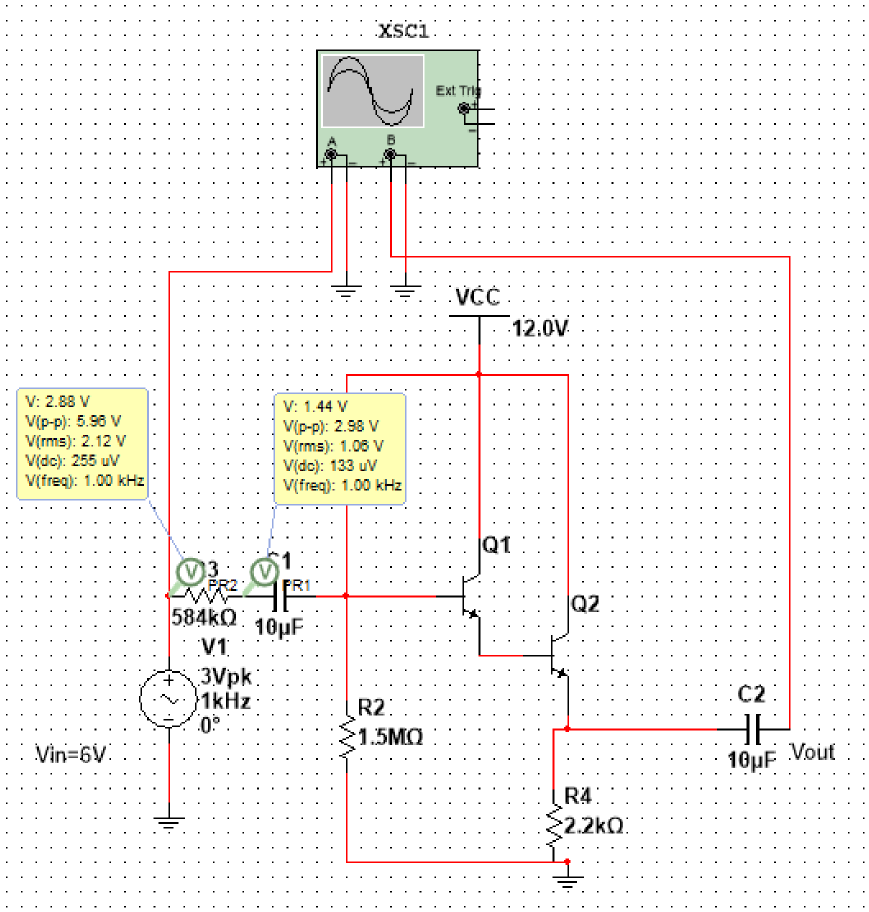
OUTPUT:



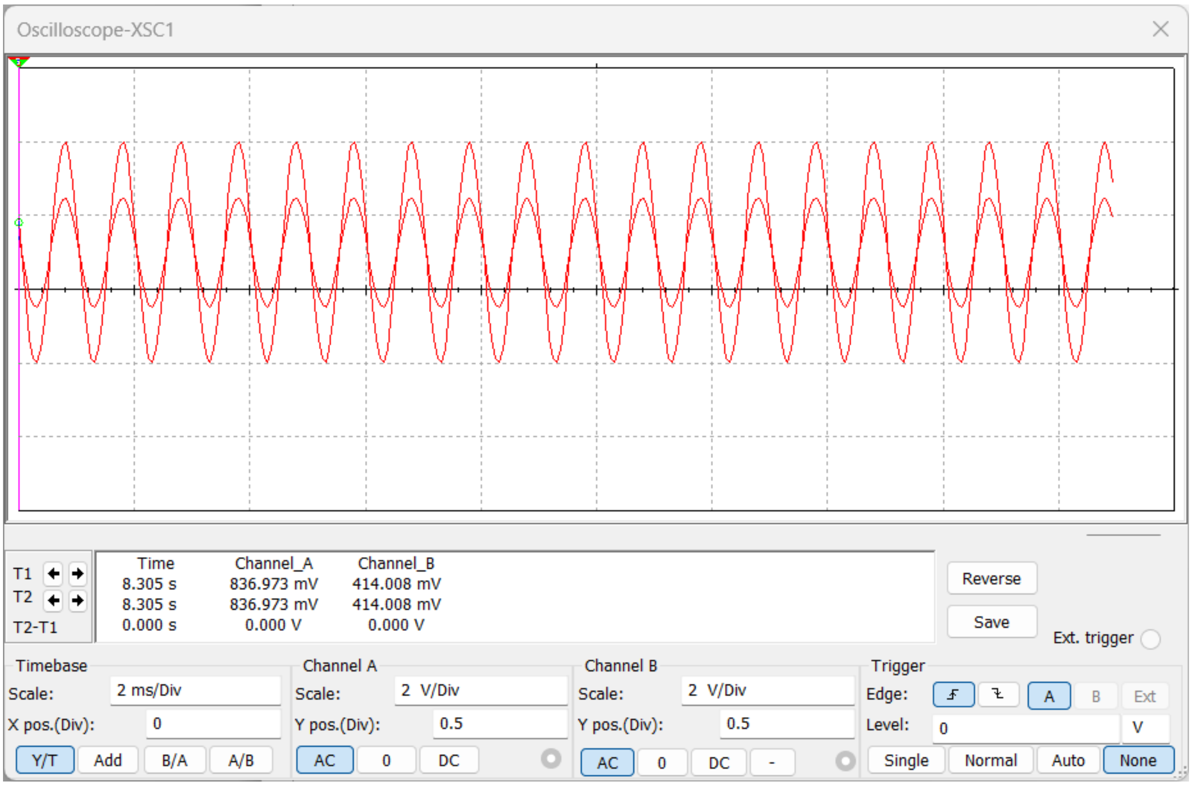
Conclusion:

After introducing source resistance Rs the input voltage decreased.

Case 2: Rin=584kΩ



OUTPUT:

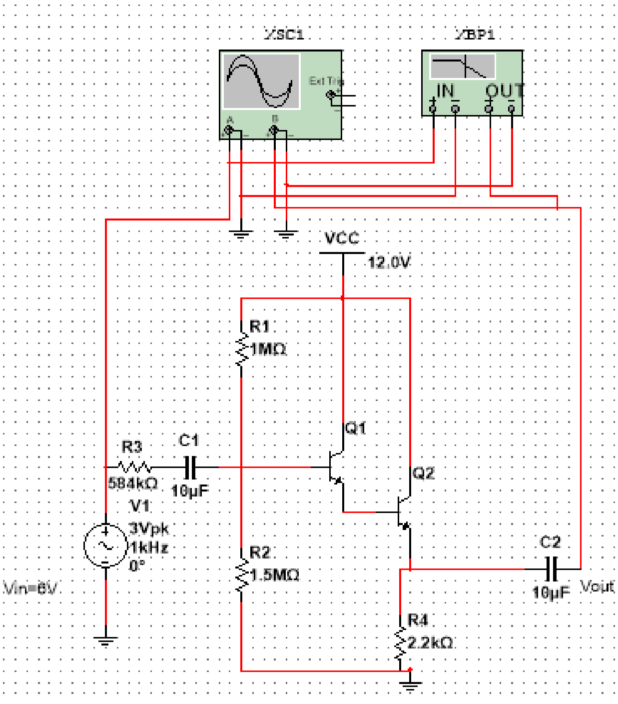


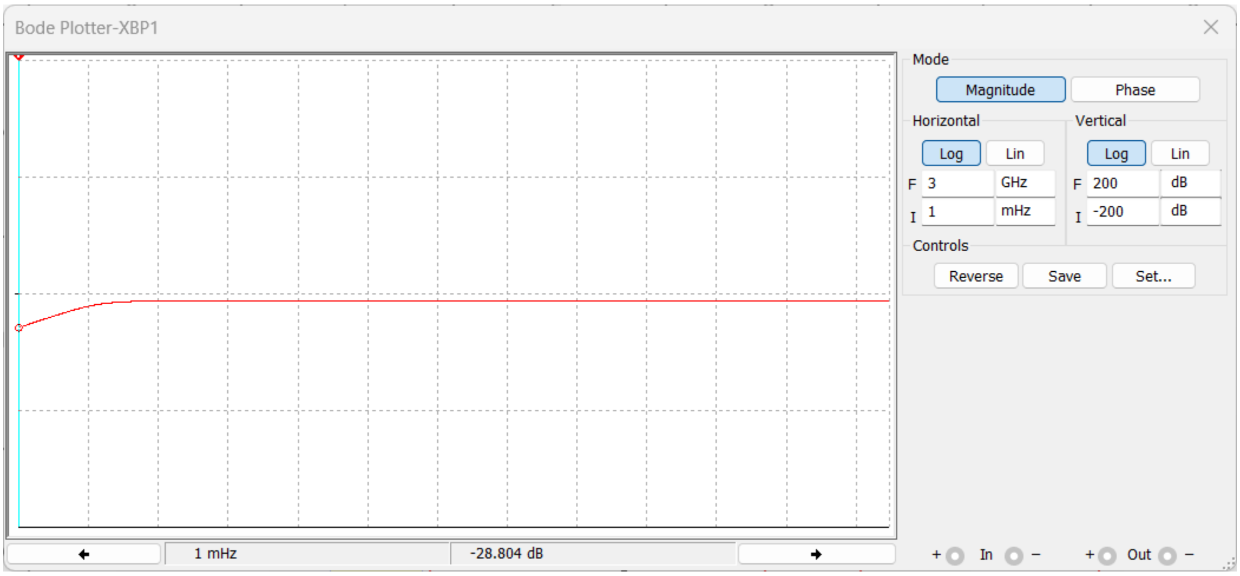
Observation:

Output is half of the input, therefore the input resistance of the amplifier isequal to the added source resistance i.e., 584k and input resistance of Darlington

Amplifier is much greater than Single CC Amplifier i.e, 10kΩ.

FREQUENCY RESPONSE:





CONCLUSION:

From the above observations, we can conclude that in a Darlington Amplifier:

Voltage Gain: 1

Current Gain: hfe x hfe = 100 x 100

Rin: 584K Ω

HARDWARE SIMULATION:

Procedure:

1. Connect the circuit as per the circuit diagram.
2. Apply the supply voltage , V_{cc}=12V
3. Make sure that the transistor is operating point in active region by keeping V_{CE} half of V_{CC}.
4. Now feed an ac signal of 3V at the input of the amplifier with different frequencies ranging from 100Hz to 300 MHz and measure the amplifier output voltage.
5. Now calculate the gain in decibels at various input signal frequencies.

Draw a graph with frequencies on X-axis and gain in dBs on Y-axis.
From the graph calculate Bandwidth.

Observations:

Darlington pair Amplifier

Frequency (in Hz)	Input (in mV)	Output (in mV)	Voltage Gain (dB)	
10	8.8V	8.8V	1	
50	8.8V	8.8V	1	
100	8.8V	8.8V	1	
200	8.8V	8.8V	1	
300	8.8V	8.8V	1	
500	8.8V	8.8V	1	
1k	8.8V	8.8V	1	Mid Frequency Gain
2k	8.8V	8.8V	1	
3k	8.8V	8.8V	1	
10k	8.8V	8.8V	1	
50k	8.8V	8.8V	1	
100k	8.8V	8.8V	1	
500k	8.5V	8.8V	1.035	
1M	8.5V	8.8V	1.035	
2M	8.5V	8.8V	1.035	
3M	8.5V	8.8V	1.035	

Conclusion: AVERAGE GAIN: 1.0085

CASE 2:

DARLINGTON PAIR WITH INTERNAL RESISTANCE :

ACCORDING TO MAXIUMUM TRANSFER THEOREM :

Maximum Power Transfer: For maximum power transfer from the source to the amplifier, the **input resistance of the amplifier should match the source resistance.** This is based on the Maximum Power Transfer Theorem, which states that maximum power is transferred when the source impedance equals the conjugate of the load impedance.

INPUT RESISTANCE (DRB)OHMS	INPUT(V)	OUTPUT(V)
0	**8.8V**	**8.8V**
100	**8.8V**	**8.8V**
1K	**8.8V**	**8.8V**
5K	**8.8V**	**8.8V**
10K	**8.8V**	**8.8V**
50K	**8.8V**	**8.8V**
100K	**8.8V**	**8.8V**
200K	**8.8V**	**8.8V**
300K	**8.8V**	**8.8V**
400K	**8.8V**	**5V**
500K	**8.8V**	**4.8V**
600K	**8.8V**	**4.7V**

CONCLUSION:

HENCE AT INPUT RESITANCE EQUALS TO 500KOHMS THE MAXIMUM POWER IS OBSERVED AS OUTPUT HAD BECOME HALF OF THE INPUT VOLTAGE